all it is, at all events, very much higher than that which was assigned to it by Rowland.*

There may, perhaps, be some doubt whether the expression used above is exactly applicable to the case of my divided ring, and small errors may possibly be introduced by the fact that the contact between the opposite faces was not quite perfect throughout.† But apart from minute accuracy of detail, the general character of the results is entirely free from doubt, and would be quite unaffected by a very large margin of uncertainty in the expression. They show that the generally accepted ideas with regard to several important points need modification.

Thus it is not true that the lifting power of an electromagnet reaches a practical limit under a comparatively small magnetising force, and that even if excited by an infinite current it could not support a weight of 200 lbs. per square inch of surface.

It is not true that the magnetisation of iron becomes sensibly constant when the magnetic force exceeds a certain moderate value.

And it is not true that the maximum of magnetic induction, if it exists at all, is represented by anything like so small a value as 18,000 units.

In conclusion, I have to express my great obligation to Lord Rayleigh for much valuable assistance and advice in the preparation of this paper.

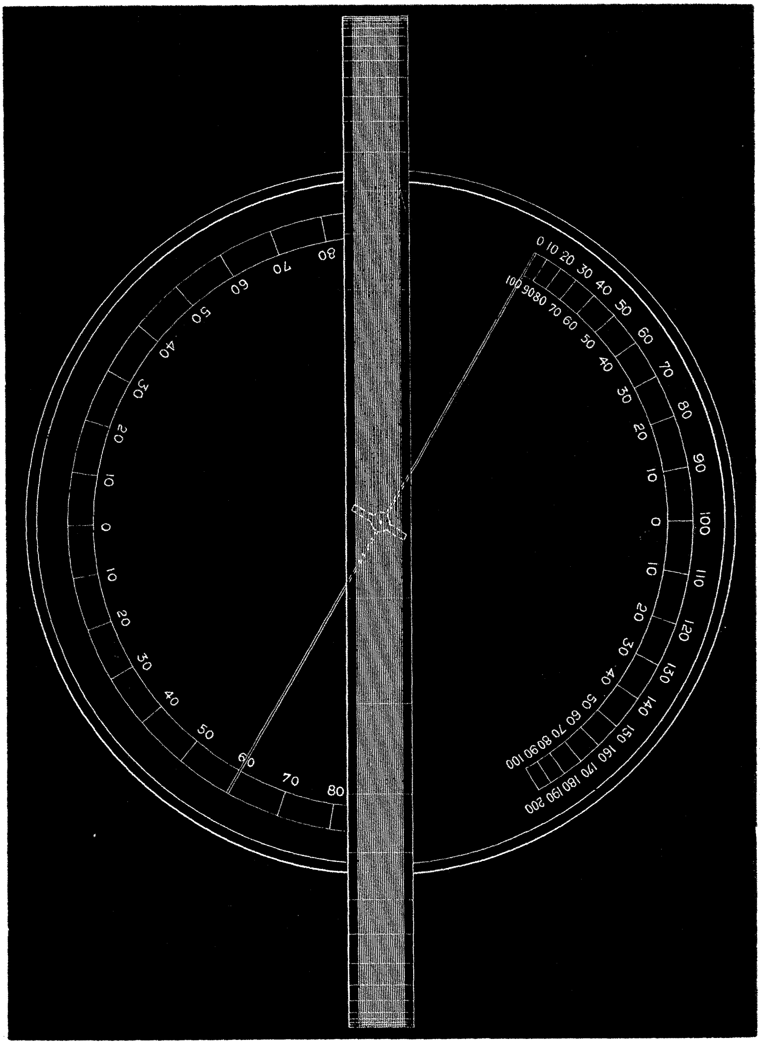
VII. "On a New Scale for Tangent Galvanometers." By W. H. Preece, F.R.S., and H. R. Kempe. Received May 6, 1886.

Tangent galvanometers are much used for the exact quantitative measurement of currents of considerable strength, such as are measured in ampères, but they are not so generally used for the measurement of smaller currents in milliampères. This arises from a notion that they are not sensitive enough; although the most sensitive instrument in practice—Sir William Thomson's mirror galvanometer—is really a tangent instrument. The ordinary forms —Joule's, Gaugain's, or Helmholtz's—are not very sensitive. Their

* It is hardly necessary to point out that if there is any limit to $\mathfrak{B}$, the susceptibility, κ, must become *negative* when the magnetic force exceeds a certain value. Maxwell appears to have considered this not impossible. See "Electricity," vol. 2, § 844.

† The close agreement of the values of κ in Table II with those obtained in the experiments of Stoletow (so far as the latter go) affords strong evidence of the accuracy of the method (see "Enc. Brit.," 9th edit., vol. 15 (1883), p. 255).

FIG. 1.



constant is about 3, that is, 3 ampères are required to produce the unit deflection of 45°.

The Post Office has for many years used a more sensitive and portable form, having a constant of 0·00214, for testing wires, batteries, and apparatus. Two scales have hitherto been engraved on the dial of the instrument, one in degrees and the other in tangent

divisions; and to avoid parallax the indicator is reflected in a mirror, so that when the image and the indicator are in one line, no error from this cause occurs.

Mr. Eden, one of the assistant electricians of the Post Office, discovered while experimenting that the galvanometer could be made more sensitive to increments of current for high deflections if it were given a false zero. In fact, if the instrument be "slewed" round so that the plane of the coil makes an angle of 60° with the meridian, then the instrument becomes twice as sensitive as it was before; and he suggested a double scale such as is shown in Fig. 1 (p. 497) to utilise this fact.

This plan has been adopted, and all tangent galvanometers in the Post Office service will be gradually altered to the new scale.

It is quite clear that it owes its increased sensitiveness to the fact that when the needle reaches its maximum deflection, its angle to the lines of force of the field is in the most favourable direction for deflection by the current. In fact, the plane of the coil becomes parallel to the plane of the needle which is then in the most uniform portion of the field.

By changing the zero of the instrument the range of movement can be considerably increased. Thus if β° be the angle which the needle normally makes with the coil, and if α° be the angle to which the needle has been deflected on the other side of the coil, then, f being the deflective force, we have—

$$f = f_1 \frac{\sin(\alpha^\circ + \beta^\circ)}{\cos \alpha^\circ},$$

where f_1 is a constant; but if the needle were parallel to the coils, then—

$$f = f_1 \tan \alpha_1,$$

therefore—

$$f_1 \frac{\sin(\alpha^\circ + \beta^\circ)}{\cos \alpha^\circ} = f_1 \tan \alpha_1^\circ.$$

Now if we have $\beta^\circ = 60^\circ$, and if the current were sufficient to turn the needle through $2\beta^\circ$, or 120°, that is, if we have $\alpha = 60^\circ$, then—

$$\frac{\sin 120^\circ}{\cos 60^\circ} = \tan \alpha_1^\circ,$$

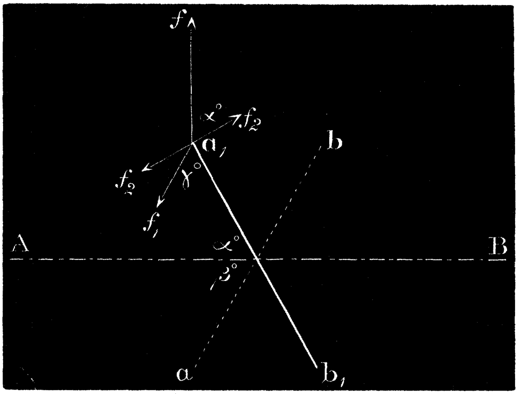
but $\sin 120^\circ = \sin(180^\circ - 60^\circ) = \sin 60^\circ$, therefore—

$$\frac{\sin 60^\circ}{\cos 60^\circ} = \tan \alpha_1^\circ = \frac{\sin \alpha_1^\circ}{\cos \alpha_1^\circ},$$

or

$$\alpha_1 = 60^\circ,$$

FIG. 2.



that is to say, the angle through which the needle would have been turned when the zero was 60° to one side of zero, would be twice what it would be if it had been deflected from the ordinary zero. The ratio of these angles, however, decreases in value, and at a certain point becomes equal to 1; that is to say, the angular deflection from the new zero is the same as it is from the old zero.

Let $$\frac{\sin(\alpha°+\beta°)}{\cos\alpha°}=\tan\alpha°,$$

therefore $$\frac{\sin(\alpha°+\beta°)}{\cos\alpha°}=\frac{\sin\alpha°}{\cos\alpha°},$$

or $$\sin(\alpha°+\beta°)=\sin\alpha°.$$

If the angle $\alpha°$ is negative, that is to say, if the angular deflection from the new zero is less than the angle $\beta°$, then we have–

$$\sin(\beta°-\alpha°)=\sin\alpha°,$$

or $$\beta°-\alpha°=\alpha°;$$

that is, $$\beta°=2\alpha°,$$

or $$\alpha°=\frac{\beta°}{2},$$

that is to say, whatever be the angle $\beta°$ (the angular distance of the new from the old zero), then a current sufficient to move the needle a distance of $\frac{1}{2}\beta°$ from the old zero would move it the same distance from the new zero. If the deflection from the old zero be less than

$\frac{1}{2}\beta^\circ$, then the deflection from the new zero will be less still; so that there is no advantage in the use of the new zero unless the deflections exceed $\frac{1}{2}\beta^\circ$.

If the angle β° be made greater than 60° then the possible angular movement of the needle becomes still further increased; but inasmuch as any increase in the length of the tangent scale brings the divisions at the ends of the scale proportionally closer together, and makes them more difficult to read from, there would be no practical advantage in making the angle larger.

A marked advantage under certain conditions is found when the new zero has such a value that the deflection from a given current causes the needle to move up to the ordinary zero, that is to say, to the position where the needle becomes parallel to the coil; in this case the instrument becomes highly sensitive, and any increase in the strength of the current produces a very considerable change in the deflection.

VIII. "On Fluted Craterless Carbons for Arc Lighting." By Sir JAMES N. DOUGLASS. Communicated by Sir WILLIAM THOMSON, F.R.S. Received June 4, 1886.

[PLATE 6.]

On the 8th December, 1858, at the South Foreland High Lighthouse, and with the direct current magneto machines of Holmes, the first important application of the electric arc light, as a rival to oil and gas for coast lighting, was carried out by the Trinity House, under the advice of Faraday. The carbons then used, and for several years afterwards, were sawn from the residuum carbon of gas retorts; they were square in section, $6\frac{1}{4} \times 6\frac{1}{4}$ mm., and the mean intensity of the arc, measured in the horizonal plane, was 670 candle units, being 17 candle units nearly per square millimetre of cross sectional area of the carbon. The crater formed at the point of the upper carbon of the "Holmes" lamp was so small that no appreciable loss of light was found to occur, and the arc proved to be very perfect in affording an exceptionally large vertical angle of radiant light for application with the optical apparatus as shown, one-third full size, in the sketch (Plate 6).

The most reliable and efficient machine that has yet been tried for lighthouse purposes is the large size alternate current magneto machine of De Meritens. The average results with these machines are as follows, viz.:—

FIG. 1.

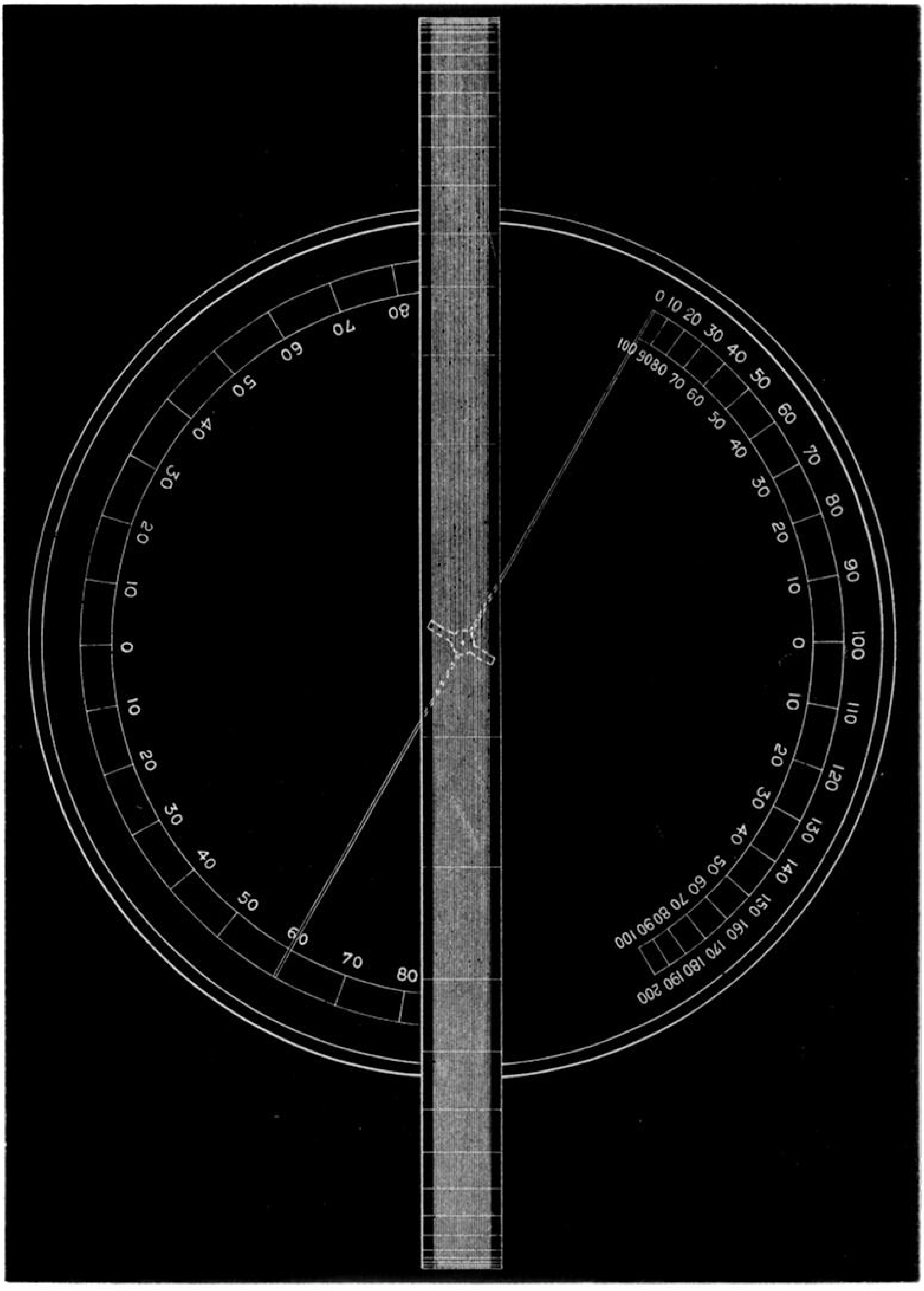

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
100 90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90 100
80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80

Fig. 2.